Observations of Io by SSI During the First Half of the Galileo Tour of Jupiter

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The Galileo Solid State Imaging (SSI) experiment has produced many new results on the volcanic activity and surface and atmospheric characteristics of Io during the initial orbits of the spacecraft through the Jovian system. The completed and anticipated observations during the first half of the nominal satellite tour (orbits G1-E6) are summarized here; science results are described in several companion abstracts [1-5].

Observation Strategy

The appearance of Io varies strongly as a function of wavelength, longitude, photometric geometry, and time. Images at low phase angles are best for mapping color and albedo variations and for comparison to images from Voyager and HST to detect changes. High-phase images best reveal forward-scattering surface and airborne materials. Observations of the bright limb are best for detecting active volcanic plumes, but many images are required to provide complete longitudinal coverage. Topographic shading is best seen near the terminator, at high illumination angles and low-to-moderate viewing angles. The highest possible spatial resolution is important for most observations. Io also glows in the dark at visible and near-IR wavelengths, and eclipse images (Io in Jupiter's shadow) have proven successful for detecting high-temperature hot spots, plumes, and Io's atmosphere [6]. Observations while Io is illuminated only by Jupitershine may enable detection of condensing frosts. Io is a very active world so repetition of observations is necessary to search for changes.

We have attempted to balance the observation objectives with the limited spacecraft resources of tape recorder space and downlink. Tools that have been very helpful include Integer Cosine Transfer compression, on-chip mosaics, and summation mode [7]. The Io observation plan described in [8] has changed in several significant ways. A tape recorder anomaly resulted in a decision to not record onto tape the high-resolution images acquired by SSI during the Io flyby after Jupiter Orbit Insertion, but there is hope of recovering high-resolution observations of Io at the end of an extended mission. Furthermore, ~20% of the tape is off-limits during the satellite tour as protection against a potential failure. This tape reduction impacted Io observations most severely in orbit E6, in which a tape-intensive plume inventory like that in G2 was eliminated. We have also modified the Io observing plan in response to new discoveries. For example, the eclipse observation in G1 was surprisingly successful, imaging 7 hot spots, several plumes, and the atmosphere along portions of the limb [6], so we have expanded and added eclipse observations in subsequent orbits.

Observations are generalized into the following categories:

MONITORING: Full-disk images in 3-4 colors at low-to-moderate phase angles, for monitoring variations in color and albedo and comparison to observations from Voyager and HST. We plan to acquire global coverage three times during the nominal tour: near the beginning (G1 + G2), the middle (E6 + G7), and the end (C9 + C10).

TOPO: Imaging optimized for highest-resolution global coverage (accumulated over whole tour) at illumination angles from 60-90 degrees. Many useful stereo pairs will also be acquired from the overlap regions [3].

6-COLOR: Full-disk images in 6 colors for compositional mapping. E4 6-color set is also a special opposition surge mapping at ~0.5 degrees phase angle, but some of the color images will not be returned due to the restricted downlink.

PLUMES: Bright-limb observations for a systematic plume inventory (G2) or targetted to suspected plume locations.

ECLIPSE: Long-exposure images when Io is in Jupiter's shadow, to search for high-temperature hot spots and diffuse atmospheric/plume glows.

JSHINE: Nightside images with Io illuminated by Jupitershine, to search for brightenings and color changes associated with condensing frosts or other phenomena.

Observations

Actual observations of Io returned from orbits G1, G2, and C3 are listed in Table 1. Anticipated Io observations from orbits E4 (12/96) and E6 (2/97) are listed in Table 2. The E4 observations have been recorded but not yet returned to the ground as of 1/8/97. All E4 and most E6

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observations should be on the ground by mid-March, 1997. (E5 is a phasing orbit with no science observations.) Plume observations (Table 1) and potential plumes (Table 2) are also tabulated; see discussion of Io's plumes in ref. [5].

References: [1] McEwen, A., et al., 17 years of surface changes on Io: Galileo SSI results, this volume. [2] Simonelli, D., et al., Io: Evidence for major variations in regolith properties, this volume. [3] Schuster, P., et al., Global shape and regional topography of Io: First Galileo results, this volume. [4] Geissler, P., et al., Spectral units and hot spots on Io, this volume. [5] McEwen, A., et al., Io: Where have all the visible plumes gone?, this volume. [6] Belton, M.J.S., et al. (1996) Galileo's first images of Jupiter and the Galilean satellites. Science 274, 377-385. [7] Klaasen, K.P., et al. (1997) Inflight performance characteristics, calibration, and utilization of the Galileo SSI camera. In preparation. [8] Carr, M.H., et al. (1995) The Galileo imaging team plan for observing the satellites of Jupiter. JGR 100, 18,935-18,956.

Table 1 Completed SSI Observations of Io

Orbit	Category	Colors[1]	Frames[2]	Res. km/px	Phase Angle	Sub-S/C Long	Plumes
G1	MONITORING	V-G-R-7	1	24	48	69	none
	MONITORING	V-G-R-7	1	15	25	338	Pele?
	MONITORING	V-G-R-7	1	13	55	264	near Volund
	ECLIPSE	C	1	10	(122)	235	Ra, Volund, Culann
	PLUMES	V-G-R	1	9	123	212	none (no Loki)
	PLUMES	V-G-R	1	10	122	227	Ra
G2	PLUMES	V	31	13-30	15-74	0-360	Prometheus, Culann
	MONITORING	V-G-R-7	4	5,10	4	175	Prometheus
C3	TOPO	C	2	3.5	31	149	Prometheus
	TOPO	C	1	2.6	35	174	Prometheus
	TOPO	C	2	2.5	39	201	Prometheus
	TOPO	C	1	3.0	47	222	none
	TOPO	C	1	4.1	60	239	none (no Ra)
	Na-cloud	C-G	1	22	169	256	Prometheus

[1]Bandpasses: V (414 nm), G (559 nm), R (664 nm), 7 (757 nm), 8 (888 nm), 9 (990 nm), C (clear, 410-1000 nm).
[2]Multiple colors on a single frame enabled by on-chip mosaics.

Table 2. Anticipated SSI Observations of Io: Orbits E4 and E6

Orbit	Category	Colors	Frames	Res. km/px	Phase Angle	Sub-S/C Long	Potential Plumes
E4	ECLIPSE	C[3]	2	18	(41)	35	many
	MONITORING	C-V-G-R	1	16	33	51	Loki, Ra
	6-COLOR	V-G-R-7-8-9	6	6,12	0.5	135	
	JSHINE	C-V-G-R	1	18	155	13	Pele, new[4]
E6	PLUMES	V-G-R	1	21	77	345	Pele
	PLUMES	V-G-R-7	1	17	54	34	Loki
	PLUMES	V-G-R-7	1	16	47	55	Ra
	MONITOR	V-G-R-7	1	11	31	94	
	MONITOR	V-G-R-7	4	10	23	165	
	TOPO	C	1	4	31	217	
	MONITOR	V-G-R-7	4	11	10	274	near Volund
	ECLIPSE	C	1	8	(54)	289	many

[3]Images during this eclipse will also be acquired in colors V, G, R, 7, and 9, but will be played back with very high compression, not expected to be useful except to aid future observation planning.
[4] Top of Pele seen in frame returned 1/9/97; new plume at long. 102, lat 20.